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Photodynamic Notes, VII. By Pliny Earle Chase, LL.D.

(Read before the American Philosophical Society, January 19, 1883.)

302. *Combined Cometary Harmonies.*

In Note 295, I showed that the primitive phyllotactic wave-tendencies in the spectrum of Comet Wells, were modified by linear oscillations, and also by two seemingly independent harmonic progressions. One of the arithmetical progressions which formed the harmonic divisors had a missing term, $1 + b$, for which Huggins observed no corresponding line. Upon further examination, I find that the completion of the harmony, by inserting the provisional wave length, $\beta_1 = a \div (1 + b) = 4583.4$, furnishes a phyllotactic bond between the two observed harmonic progressions. For $4583.2 = \gamma + \frac{3}{5} (\beta\text{-}\gamma)$, and β_1 represents a projectile locus of rotary oscillation between β and γ. Moreover, the locus of the center of rotary oscillation, $\frac{2}{5} (\beta - \gamma) = 50.8$, helps to determine phyllotactically the value of α, since $\frac{3}{8} (\alpha - \beta) = 50.625$.

303. *Telephonic Analogy.*

The telephone shows the influence of harmonic oscillations in successive media of different elasticity, and it may perhaps furnish suggestions which will prove useful in investigating the persistence of solar energy. The atmospheric sound-waves strike the diaphragm, exciting metallic sound-waves; these, in the mechanical telephone, are transmitted through the wire to the receiving diaphragm, where they excite new atmospheric sound-waves, which awaken audible sound-waves in the tympanum of the listener. In the electric telephone, the metallic sound-waves modulate the electric waves, which are forwarded with much greater speed than the ordinary metallic waves, affecting the air in the receiver and the ear of the hearer in the same way as in the mechanical telephone. In a communication to the American Philosophical Society, March 21, 1873 (*Proc.*, xiii, 149-54), I pointed out harmonies of light and sound, which, with the identity of Note 280, account for these successive transformations. Berthelot's explosive waves, (Notes 276, 278) must similarly produce luminous and electrical waves in Sun's atmosphere, and thus contribute towards the maintenance of solar radiant energy.

304. *Amount of Solar Thermal Radiation.*

A. Ritter, (*Wied. Annalen*, 1882, No. 10), estimates the solar radiation at 14,000 calories per square metre per second. This is equivalent to 3976100 foot-pounds per square foot. If the Sun were surrounded with an atmosphere like our own, but of superficial density proportional to the gravitating pressure, the pressure would be about 420 pounds per square foot. The radiation, therefore, would be sufficient to maintain a constant circulation of the entire atmosphere, at the rate of 9467 feet per second, which is but little more than half as great as the explosive velocity of

H_2O (Note 298), about 1.56 times the molecular velocity of hydrogen, and about $\frac{4}{3}$ of the equatorial velocity of Sun's rotation. All of these relations are of an order of magnitude which tends to confirm the belief that solar radiation and gravitating circulation represent equal actions and reactions, and that dissociation and recombination within Sun's photosphere may maintain luminous, thermal, and actinic æthereal oscillations.

305. *Cometary Fugues.*

The spectral harmonies in Comet Wells (Notes 295, 302), as well as the planetary harmonies on which I based some of my successful predictions, (Notes 33, 133, 261, etc.), are of the nature of fugues, or harmonies which follow each other at certain intervals which are determined by rhythmic laws. The principle of the fugues being susceptible of indefinite extension in two directions, it is not strange that even the stars should bear witness to it (Notes 24, 46, 85, 111-5, 130-2, 154-5, 168, 262). Among the intra-modular positions which have verified my anticipations, two (Note 32) are known to be cometary; two represent the places of brilliant bodies which were seen by Watson and Swift, during the total solar eclipse of 1868, but which, having been seen by no subsequent observer, may also have been cometary; two were deduced from a comparison of planet-like shadows crossing Sun's surface, and one from sun-spots of various forms, which have a harmonic period; seven indicate periods which are in strict harmonic accordance with motions of our stellar system's chief centres, of nucleation (Sun), of condensation (Earth), and of nebulosity (Jupiter). All the indications seem somewhat likely to be cometary, rather than planetary, and thus confirmatory of Herschel's theory of nebular "subsidence." As the statements of these confirmations of cosmical harmonic motion are scattered among various papers, I collect them here, in order to show, at a glance, the character of the various accordances.

Harmonic.	Observed.	Authority.	Notes.
296.52	285.2	Forbes	32, 261
94.38	96.7	Forbes	32
.27	.267	De la Rue, S. and L.	33
.207	.209	Kirkwood	"
.185	.180	Gaillot	"
.167	.164	Gaillot and Mouchez	"
.167	.163	Stewart	133
.141	.140	Earth's day and year	33
.121	.123	Von Oppolzer	"
.1065	.1069	Solar rotation, $v_\gamma = v_\lambda$	"
.0199	.0195	Earth's day	"
.0109	.0109	Jupiter's day	"
.0076	.0074	Solar oscillation	"
.0058	.0057	Solar "subsidence"	"
.0047	.0047	Sun's surface	"

The seven loci which represent harmonies of nucleation, condensation and nebulosity, illustrate the tendency of waves in elastic media to maintain and propagate motions which are harmonically dependent upon their loci of origination.

306. *Velocity of Incandescence.*

Draper found that all solid bodies become incandescent at the same temperature, reaching red heat at 977° F., or at the absolute temperature of 1436°.4 F. This indicates a lift, against earth's superficial gravitation, of $h = 1436.4 \times 772 = 1,108,901$, or a velocity of $v = \sqrt{2gh} = 8435.9$ feet per second. The mean velocity of hydrogen molecules is 6050 feet, which is $.717 \times 8435.9$ feet. The velocity of incandescence is, therefore, within 1½ per cent. of the parabolic orbital velocity which would correspond to a circular orbital velocity equivalent to the molecular velocity of hydrogen, ($6050 \times \sqrt{2} = 8556$). In other words, if the mean velocity of hydrogen, at the standard temperature, is a mean orbital velocity, its increase to a velocity of infinite projection would give the velocity of incandescence, or the velocity which creates æthereal disturbances of sufficient magnitude to cause luminous radiations. These disturbances are of the same order of magnitude as those which are indicated in Note 304, and they furnish new reasons for believing that the hypotheses of Siemens and Berthelot (Note 278) may suffice to account for the conservation of energy which is indicated by the fundamental equality, $v_\lambda = v_\varepsilon = v_\gamma$, (Note 280).

307. *Tails of Comets.*

Proctor (*Contemp. Rev.*, Oct. 1882) states some of the chief difficulties attending the attempts which have been made to explain the formation of comets' tails, by materials thrown off from the nucleus by solar repulsion, by actinic clouds, by tactic arrangement, or by electricity, and speaks of certain phenomena "which force upon us the belief that they are phenomena of repulsion, though the repulsive action is of a kind not yet known to physicists." He inclines, with Huggins, and "an American astronomer" whose name is not given, to attach great importance to electric action or something of a similar nature. He cites the notice by Huggins, of the remarkable persistence of meteoric trains in the rare upper atmosphere, where they sometimes last for more than three-quarters of an hour. The evidences of repellent action such as might be explained by electricity, of gravitating re-action, of luminous radiation from the sun in the direction of the axis of the tail, and of a general curvature of the extremity of the tail as if it were retarded in some way, are such as to need consideration in any attempts at explanation. All of these phenomena, except the one last named, may be correlated by the fundamental equality of Note 280. The curvature of the tails may be due to persistence of oscillation, combined with æthereal tendencies to orbital motion in times varying as $r^{\frac{3}{2}}$. The extreme tenuity of cometary matter points to a relative elasticity which is much greater than that of air, and which must, therefore, be peculiarly subject to harmonic oscillations; the waves of light, like auroral flashes, which have often been seen in the tails, point to electric, phosphorescent, and luminous rhythms; the frequent interchanges between the tail and the nucleus, as well as the rupturing explosions and the formation of nucleoli, must be subject to the laws of phyllotactic and gravitating rhythm; if the æther is material, it must be influenced by rotational and orbital tendencies, even if its elasticity is so great as to prevent actual orbital motion, and hence the "actinic shadows" may be curved.

308. *Other Cometary Considerations.*

Phyllotactic distribution in organic growth, in frost tracery and other forms of crystallization, and in satellite or planetary groupings, points to a continuance of tendency, over periods which are proportional to the resistance interposed by the inertia of the particles or masses which partake of the distribution. When the inertia is very small, as in the æthereal interferences to which spectral lines are attributed, the adaptation to requirements of "extreme and mean ratio" may be nearly or quite instantaneous. We may, therefore, reasonably look for evidences of adaptation, such as are shown in Notes 295, 302 and 305, as well as for various modifications by other forms or kinds of harmonic tendency. Refraction of energy (Note 286), and Draper's "latent light," may also contribute to the curvature of tails, in a medium which is perhaps more tenuous than the "fourth form of matter," and which imparts sympathetic vibrations to the adjacent æther.

309. *Effects of Cometary Eccentricity.*

The tendencies to æthereal rotation and revolution about stellar centres may, perhaps, be so adjusted to other oscillatory tendencies as to oppose little or no resistance to planetary motions in orbits of small eccentricity. Most of the cometary orbits, however, are so eccentric that their *vis viva*, at every stage of their journey, is nearly twice as great as it would be if their paths were circular. Such amount of living force is more than sufficient, whenever there is any appreciable resistance, to produce and maintain luminous and thermal phenomena, of the same kind as occur in the explosive combinations of gases. The orbital energy may be resolved into two rectangular components, one of which passes through the sun, while the other is tangential to the path of the revolving æther. The latter may adapt itself so readily to the æthereal vortices as to make no disturbance; the former being perpendicular to the æthereal track, must encounter a continual resistance and retardation, unless it is compensated by luminous, electric, gravitating, or other kinetic undulations.

310. *Eccentricity at Mean Centre of Inertia.*

The fundamental identity (Note 280) represents a uniform velocity, and we may, therefore, look for evidences of primitive photodynamic influence in the uniform velocities of important cosmical centres. One of these evidences is found in the proportion,

$$t_\alpha : t_\beta :: T_\alpha : T_\beta$$

In this proportion, t_α, is the orbital time at the chief centre of condensation (Earth); t_β, the orbital time at the centre of primitive nebulosity (Jupiter); T_α the time in which a photodynamic wave would traverse the secular eccentricity at the primitive centre of planetary inertia (Saturn); T_β the time in which the wave would traverse Saturn's semi-axis major. The accordance is shown by substituting the values, which give the proportion,

$$365.2564 : 4332.5848 :: .08431 : 1$$

Stockwell's estimate of Saturn's secular excentricity is .08433. T_α and T_β also represent the comparative living forces which would project a planet, against uniform resistance, through the distances traversed by the respective photodynamic waves.

311. *Harmonies of Terrestrial Acceleration.*

The cyclic oscillations at the chief centres of condensation and nebulosity would tend to produce corresponding accelerations through the action of central forces. An important harmony, which introduces the *vis viva* of acceleration, is shown in the proportion,

$$a^2_\alpha : a^2_\beta :: t_\alpha (t_\alpha + t_\beta) : t_\beta.$$

In this proportion, a_α is the rotary acceleration which Earth has undergone according to the nebular hypothesis; a_β, the acceleration according to Herschel's theory of "subsidence;" t_α and t_β have the same values as in the foregoing note. The value of a_α is $\left(366.2564 \div 2\pi\sqrt{\frac{r}{g}}\right)^{\frac{2}{3}} = 338.22$; $a_\beta = 86164.1 \text{ sec.} \div 2\pi\sqrt{\frac{r}{g}} = 16.983$. Substituting these values we get

$$338.22^2 : 16.983^2 :: 396.62 : 1$$
$$396.62 : 366.2564 :: 1.0829 : 1$$
$$t_\alpha + t_\beta : t_\beta :: 1.0843 : 1$$

This harmony furnishes additional grounds for rejecting Delaunay's hypothesis of terrestrial retardation by tidal friction.

312. *Earth's Accelerated Rotation.*

I have already referred to the inconsistency of Delaunay's views with the nebular hypothesis. According to the form of that hypothesis which was taught by Laplace, at the time of nebular rupture the day and year should have been sychronous. In order to establish such sychronism at the present time, Earth's radius would need to be expanded ($\sqrt{366.2565} = 19.138$) times, and Laplace's terrestrial limit would be

$$\left(1 \text{ year} \div 2\pi\sqrt{\frac{r}{g}}\right)^{\frac{2}{3}} r, \text{ or } 338.218r.$$

This represents a comparative acceleration of the velocity of rotation which may be very closely represented by the quotient of (Jupiter's year × Earth's year) by (the sum of Jupiter's and Earth's years × Earth's day), or by $4332.5848212 \times 365.2563582 \div (4332.5848212 + 365.2563582) = 336.858$. As this equation introduces considerations of the chief centres of nucleation, nebulosity and condensation which must still be efficient, it furnishes another reason for caution in dogmatizing about tidal friction and thermodynamic laws.

313. *Joint Relations of Sun, Jupiter, Earth and Venus.*

A succession of important harmonic motions is shown in the relations of solar mass and density, which make $g_0 t_0 = v_\lambda$; the relation of Sun's mass to Jupiter's mass which makes Sun's surface the projectile locus, or secular perihelion centre of gravity, of Sun and Jupiter; the relations of terrestrial mass and density which make $g_3 t_3 \doteq$ circular orbital velocity at the mean centre of gravity of Sun and Jupiter; and the relation of Venus to Earth which makes the incipient orbital *vis viva* of Venus (at secular aphelion) equal to Earth's mean orbital *vis viva.* If we adopt the British Nautical Almanac estimate of Sun's apparent semi-diameter (961.″83), the accordance of harmonic and computed values will be as follows:

	Harmonic.	Computed.	Authority.
Sun ÷ Venus	427326	427240	Hill.
" " Earth	330463	331776	(Oscillatory)
" " Jupiter	1047.879	1047.879	Bessel.

Earth's semi-axis major, 92,661,600.

314. *Joint Relations of Sun, Jupiter, Earth and Saturn.*

Alexander's harmony ($m_5 d_5^2 \doteq m_6 d_6^2$) is rendered more significant by Saturn's orbital situation at the nebular centre of planetary inertia, $(\Sigma\, md^2 \div \Sigma\, m)^{\frac{1}{2}} \doteq \rho_6$. The slight deviation from exact accordance is very nearly, if not precisely compensated by the equation, Sun × Earth × Saturn $\doteq$ Jupiter^3. Alexander's approximation gives, $m_0 = 3522.33\, m_6$; the other approximation gives, according to the foregoing note, $m_0 = 3481.86$; the arithmetical mean being $m_0 = 3502.1$, which differs by less than $\frac{1}{70}$ of one per cent. from Bessel's estimate. If ρ_5, ρ_6 represent Stockwell's estimates of the mean perihelia of Jupiter and Saturn, Bessel's estimates of their respective masses, and the equation (Sun ÷ Jupiter) × (Earth ÷ Jupiter) $= (\rho_5 \div \rho_6)^2$, give $m_0 \div m_3 = 330240$. The harmonic accordances which were given in Note 310 corroborate these evidences of joint relations, and encourage a search for modifications by combined harmonies in other cases.

315. *Photodynamic Relations of Uranus and Neptune.*

The increasing number of harmonic influences with increasing distance from Sun, was illustrated in my *Relations of Mass,* (*Proc. A. P. S.*, xviii, 231), and in Note 156. A connection in which the harmonies of luminous undulation are more directly shown, gives the following relations:

$$(\rho_7 + \rho_3) \div 2\pi\sqrt{\frac{r_0}{g_0}} = v_\lambda$$

$$m_7 : m_3 : : \sqrt{\rho_3} : \sqrt{r_0}$$

$$\rho_7^2 : \rho_3^2 : : 1 \text{ year} : 1 \text{ day}$$

$$m_7 : m_8 : : p_7 : a_7$$

Stockwell's estimates of p_7 and a_7 (secular perihelion and secular aphelion of Uranus) are 17.687929 and 20.679233. The closeness of harmonic accordance is shown in the following comparison, in which I have used Struve's constant of aberration and the estimates of Note 313.

Velocity of light	$.43073r_0$	$.43077r_0$	Struve.
Semi-axis major of Uranus	$19.184\rho_3$	$19.138\rho_3$	Stockwell
Sun ÷ Uranus	22592	22600 ± 100	Newcomb.
" " Neptune	19324	19380 ± 70	Newcomb.

The division of the outer planetary belt is, therefore, such that the aphelion mass is in accordance with aphelion influence at the inner portion of the belt, while the perihelion mass is in accordance with perihelion influence. The further considerations of Note 156 add to the interest of this relationship.

316. *Joint Relations of Sun, Earth, Venus and Moon.*

The three foregoing notes seem to show that the harmonic influence of the chief centre of condensation (Earth) upon planetary masses, has been greater than that of the centre of nebulosity (Jupiter). We may, therefore, naturally look for additional illustrations of terrestrial influence within the dense belt, such as are given in Notes 8, 85, 156, 246-7, 254-6, 313. The estimate of μ, in Note 246, would become 1 ÷ 81.08 if we adopt the value of ρ_3, which is given in Note 313. This value, if substituted in Note 8, would give 4.952 miles for the height of Earth's homogeneous atmosphere, through the proportion

$$\pi^2 \times 81.08 : 1 : : r_3 : .0012496r_3 : : 3962.8 : 4.952$$

The harmonies of Note 85 may well be studied in this connection. Stockwell's value for the secular perigee of Venus is $.9322648\rho_3 - .7744234\rho_3 = .1578414\ \rho_3 = 14{,}625{,}840$ miles $= 1.0252 \times (3 \times 4 \times 5)^2 \times 3962.8$ miles. The solar modulus of light, according to the same estimates, is $2213.37\rho_3 = 1.00073 \times 4 \times (3 \times 4 \times 5)^4 r_3$.

317. *The November Meteors.*

The relations which were pointed out in Note 315 may be supplemented by cometary indications of a character somewhat like those which led Forbes to his deduction of two supra-Neptunian loci (Notes 32, 305). The secular aphelion of Uranus, or its locus of incipient subsidence (20.679233), represents a cometary major axis with a period of 33.2473 years. The period of the great "star-shower" of November 1833 and 1866 has been computed at "about 33.25 years." A similar cometary major axis (20.7072688), with a period of 33.315 years, would exactly represent, by its apsidal loci, the mean positions of Mars and Uranus. The special photodynamic indications of the first equation in Note 315, may be fairly presumed to have exerted an influence on each side of the central track, which would be sufficient to account for all of the approximations that have been indicated.

318. *Geological Time.*

Dr. Haughton (*Am. Journ. Sci.*, Nov. 1882) read before the American Association, in August, 1882, some "New views of Mr. George H. Darwin's Theory of the Evolution of the Earth-Moon System, considered as to its bearing on the question of the duration of Geological time." He cites Sir William Thomson's views as to the present rigidity of the earth, the probability that Saturn's rings consist of swarms of discrete meteoric stones, the low specific gravity of the outer planets, the recent researches connecting the periodic swarms of shooting stars with comets, Huggins's comparisons of the spectroscopic appearances of comets and incandescent portions of meteoric stones, and Prof. H. A. Newton's hypothesis that the asteroids may be extinct comets, to justify the position "that the earth and moon when they separated from the solar nebula, did so as a swarm of solid meteoric stones, each of them having the temperature of interstellar space." He then shows that the meteoric problem resembles the hydrodynamical problem, giving equations "in all respects similar to those derived by Mr. Darwin, from the hypothesis of a viscous earth" and placing "a cool earth and almost indefinite time at the disposal of geologists." These views are in accordance with Herschel's theory of subsidence, which I have found so abundantly illustrated by the actions and reactions of gravitation and æthereal elasticity (*Proc. A. P. S.*, ix, 283–8, 345–9, 355–60; x, 261–9, 368–79; xi, 103–7; xii, 392–417, 518–22; xvi, 184–92; xvii, 294–307, *et al*). Dr. Haughton refers to Prof. Newton's application of the same theory to account for the asteroids and some of the satellites, but he has made no allowance for the modifications of planetary and satellite arrangements which would result from harmonic motion.

319. *The Key-Note of Nature.*

Gardiner says (*Music of Nature*, 2d, Ed. p. 417): "In the fifteenth century, music was generally written in the key of F, and its relative D minor. This order of sounds was first adopted, probably on account of its being the most familiar to the ear, as it will be seen that the cries of animals, the buzzing of insects, the roar of storms, the murmurs of the brook, and some of the grandest sounds of the natural world, are to be referred to this harmony and may be denominated *The Key of Nature.*" In 1873, (*Proc.*

A. P. S., xiii, 151), I showed the accordance between the wave length of the principal Frauenhofer lines and of the homonymous notes of the twenty-third musical octave, the greatest difference being $2\frac{2}{3}$ per cent., and the closest approximation being at F, where the difference is less than $\frac{3}{7}$ of one per cent. In the arithmetical mean, the difference is less than $\frac{1}{7}$ of one per cent.; in the geometrical mean the accordance is exact. Langley, in a communication to the British Association, at Southampton, reported experiments which show a fundamental solar "tint which must approximately represent that at the photosphere, and which is most similiar to that of a hue near Frauenhofer's F." (*Am. Jour. Sci.*, Nov. 1882). See also Notes 41, 42, 235.

320. *Limit of Thermal Velocity.*

In Notes 58, 61, 62 and 102 I introduced some thermodynamic considerations which were based on interstellar photodynamic influence. In April 1865, (*Proc. A. P. S.*, x, 101) I called attention to the fact that "even the thermal currents are occasioned simply and solely by the varying gravitation of fluids of varying density," and in nearly all my physical papers I have been guided by the belief that all ultimate energy is radiant from or toward kinetic centres, the various forms, (luminous, thermal, electric, gravitating, etc.) being merely due to subordinate modifications of primitive radiations. The simultaneous radiation of light and heat from the Sun, the "Thomson Effect" (see *Am. Jour. Sci.*, xxiv, 379–87), and the phenomena of thermo-electricity, furnish strong *a priori* grounds for believing that the limit of thermal velocity, v_θ, is the same as the limit of luminous velocity, v_λ.

321. *Extension of Fundamental Equality.*

In throwing a ball into the air, the thermal equivalent of the projectile force is equal to the product of the mass by the sum of the retardations which result from gravitating influence, atmospheric resistance and all other opposing circumstances. In solar rotation, all the solar superficial particles are alternately projected from and drawn towards the chief centre of gravity of the system, in cyclical periods of half-rotation. The thermal equivalent of this projection represents the whole work of gravity for the time, $\frac{mgt^2}{2}$, and the corresponding velocity, v_θ, is equivalent to the velocity of light. This gives the following extension of the equation in Note 280:

$$v_\lambda = v_\varepsilon = v_\gamma = v_\theta.$$

The combination of centripetal and centrifugal tendencies which produces solenoidal terrestrial currents (Note 274), may, perhaps, suggest considerations which will be serviceable in general electrical research, and so lead to important developments of this fundamental equation.

322. *Disturbed Attraction.*

R. Lamont (*Jour. of Science*, Oct. 1882), says, "If we disturb the attraction which holds together the atoms of a chemical compound,. whether it be in the solid, the liquid, or the gaseous state, we have this same emanation of light and heat. If, then, these great effects can be produced in our laboratories, what must result in our solar system from the continual struggle between attraction and centrifugal force?" I attacked the view that weight can be predicated of bodies at rest, as early as 1864 (*Proc. Am. Phil. Soc.*, ix, 357), and in February, 1868, I gave a summary of various phenomena which may be simply coördinated by the theory that motion, rather than rest, is the natural state of matter (*Proc. Am. Phil. Soc.*, x, 377–9). Although similar views had often been advocated by others, no attempt seems to have been made to confirm them by numerical measurements, prior to my investigations, which began in 1863 (*op. cit.*, ix, 283–8).

323. *Lunar Barometric Tides.*

The correlations of gravitating and magnetic tides (Notes 116–22), lend interest to Bergsma's observations of the lunar atmospheric tide at Batavia, 1866–80 (See *Nature*, Nov. 23, 1882, p. 79), a tide which appears to have been first observed by Luke Howard, in London. Assuming the lunar day to begin at the Moon's upper transit, the following are the phases above or below the mean, expressed in millimetres :—

	mm.		
1st max.	+ .057	at lunar hour	1
1st min.	— .053	" "	7
2d max.	+ .064	" "	13
2d min.	— .060	" "	19

Buchan's isobar of 29.9 in. = 759.45 mm. passes through the Malayan Archipelago. This is 6491 times the mean range (.117) of lunar disturbance, which is much greater than can be explained by simple gravitating tide. It is, however, in simple harmonic relation to the square of the mass. If $m_3^2 : \mu^2 :: 6491 : 1$, $m_3 = 80.56\mu$.

324. *Lunar-Tidal Rainfall at Batavia.*

"The influence of the moon's phases on the rainfall [at Batavia] is quite decided ; for while the mean daily rainfall is .205 in., it rises at full moon to .248 in., from which time it gradually falls to .181 in. at the third octant, rises to .212 in. at the fourth octant, then falls to .184 in. at the fifth octant, and finally rises gradually to the maximum at the time of new moon. The important conclusion follows that the attractive influence of the moon, and consequently that of the sun, must be taken into account as factors concerned in bringing about oscillations of the barometer." These evidences of lunar-tidal influence upon rainfall are greater than those which I found at Philadelphia (*Proc. Am. Phil Soc.*, x, 523–37), about the same as at Barbadoes (*Ib.*, xiv, 195–216), but less strongly marked than at Lisbon (*Ib.*, xii, 178–90), and at San Francisco (*Ib.*, xii, 523–42).

325. *The Neptuno-Uranian Belt.*

All the proposed forms of the nebular hypothesis seem to require evidences of retrograde motion, such as are shown by the outer planets of our system. The successive harmonic influences of central condensation, conversion of orbital into rotary motion, incipient projection and incipient subsidence are shown by the proportions which were given in Note 315. If we take the oscillatory estimate, $m_0 = (2 \times 3 \times 4)^4\ m_3$, instead of the estimate in Note 313, we get $m_0 = 22656 m_7 = 19379 m_8$; $\rho_7 = 19.138 \rho_3$. Newcomb's mass-estimates are $m_0 = (22600 \pm 100) m_7 = (19380 \pm 70) m_8$. The observed value of ρ_7 is $19.184 \rho_3$, which is about $\frac{1}{4}$ of one per cent. greater than the harmonic value.

326. *Terrestrial Magnetic Vis Viva.*

Equation (1) of Note 91 may be modified by regarding v_0 as a mean proportional between Earth's mean orbital velocity and the velocity of light, and substituting the mass of the Telluric system, m_a, for Earth's mass. We then have,

$$m_0 v_0^2 : m_a v_\lambda^2 : : m_a v_\lambda^2 : m_5 v_0^2,$$

substituting $v_\lambda = \rho_3 \div 497.827$; $v_3 = 2\pi\rho_3 \div 31558149$; $m_0 = 1047.879 m_5$; we get $m_5 = 311.672 m_a$; $m_0 = 326594m$, which differs by about $\frac{1}{3}$ of one per cent. from the magnetic estimate of Note 2 (327710). The identity of the velocity of electro-magnetic disturbance (*Maxwell, Electricity and Magnetism*, § 784) with the velocity of light, lends interest to this approximate coincidence. If we estimate $m_3 = 81.08\mu$, these two values of m_a give

$$m_0 = \frac{82.08}{81.08} \times 326594 m_3 = 330622 m_3\ ;\ \rho_3 = 92678000 \text{ miles.}$$

$$m_0 = \frac{82.08}{81.08} \times 327710 m_3 = 331752 m_3 ;\ \rho_3 = 92783400 \quad \text{``}$$

The latter estimate of ρ_3 differs by less than $\frac{1}{400}$ of one per cent. from the value which is indicated by centres of nodal oscillation (Note 91).

327. *Cosmic and Chemical Harmonic Motions.*

A harmony which involves considerations of the conversion of orbital into rotary velocity, projectile *vis viva*, inertia of central condensation, and energy of chemical combination, is shown in the proportion

$$\rho_a : \rho_0 : : g_a : g_0 : : r_3^2 : h^2$$

in which $\rho_a =$ Earth's primitive locus of orbital projection, or secular perihelion (Stockwell's estimate of secular eccentricity and the Brit. Naut. Alm. estimate of Sun's apparent semi-diameter give $\rho_a = 200.385 \rho_0$); g_a = mutual gravitating acceleration of two equal particles at distance h ; g_0 = like acceleration at distance r_3 ; h = theoretical height of secondary centre of oscillation in explosive combination (Note 16). Solving the proportion, we get, $h = 279.943$ miles ; $\rho_3 = 92739000$ miles ; $m_0 = 331280 m_3$.

328. *Comparison of Harmonic Mass-Estimates.*

The estimates of planetary mass in Notes 313–5 are, in some respects, more simple than those in Note 156. This is especially the case with Uranus and Neptune.

	Note 156.	Notes 313–5.	Computed.
Sun ÷ Venus.	427630	427326	427240
Sun ÷ Earth,	331668	330463	331776
Sun ÷ Jupiter,	1047.879	1047.879	1047.879
Sun ÷ Saturn,	3503.22	3502.1	3501.6
Sun ÷ Uranus,	22602	22592	22600
Sun ÷ Neptune	19392	19324	19380

The relations of mass, density, and time, at the stellar centre of the system, are determined by the velocity of light; those at the chief nebular centre are influenced by the first harmony; those at the chief centre of condensation introduce the two preceding harmonies; those at the centre of planetary inertia show the combined influence of luminous undulation, nucleation, nebulosity and condensation. Venus and Uranus are rhythmically influenced by the chief centres of nucleation and condensation; Neptune is similarly influenced, though less directly, through its belt-connections with Uranus.

329. *Comparative Harmonic Estimates of Earth's Mass.*

In Note 15 I gave a summary of eighteen kinetic estimates of Earth's semi-axis major, giving the mean value, $\rho_3 = 92737100$ miles. Subsequent harmonic estimates, introducing various nodal influences which must be obviously operative, furnish data for the following comparisons:—

			Sun ÷ Earth.	ρ_3.	
Chemical energy,	Note	16	331631	92,772,200	miles.
Oscillatory “	“	23, 91	331776	92,785,700	“
Inertia	“	152	331890	92,796,300	“
Rotating energy,	“	313	330463	92,661,600	“
Luminous “	“	326	330622	92,678,000	“
Magnetic “	“	326	331752	92,783,400	“
Gravitating “	“	327	331280	92,739,000	“

The mean values are 331345 ± 137, and 92,745,200 ± 12900. The latter value differs by less than $\frac{1}{114}$ of one per cent. from the one given in Note 15.

330. *Nodal Influence of Jupiter.*

The joint influence of Sun and Jupiter which was shown in Note 328, may be further illustrated by various nodal relations of planetary apsides. I indicated the importance of harmonic motion in determining apsidal positions, in a communication to the American Philosophical Society, April 2, 1869, more than eight years before Professor Stephen Alexander called the attention of the National Academy to the subject (*Proc. Am. Phil. Soc.*, xi, 103–7; xii, 403–7, 412, 520; xiii, 146, 196 (11); xiv, 635; etc.).

α. Jupiter's locus of incipient subsidence (secular aphelion), is nearly a mean proportional between Neptune's locus of incipient subsidence and Earth's semi-axis major.

β. Jupiter's mean subsidence-locus (mean aphelion) is nearly a mean proportional between Neptune's locus of incipient subsidence and Earth's mean projectile locus (mean perihelion).

γ. Jupiter's mean subsidence-locus is nearly a mean proportional between the semi-axes major of Mars and Uranus.

δ. Jupiter's semi-axis major is nearly a mean proportional between the mean projectile locus of Mars and the semi-axis major of Uranus.

ε. Jupiter's semi-axis major is nearly a mean proportional between the incipient subsidence locus of Uranus and the incipient projectile locus (secular perihelion) of Mars.

ζ. Jupiter's mean projectile locus is nearly a mean proportional between the incipient projectile-locus of Uranus and the mean projectile-locus of Mars.

η. All of Jupiter's orbital loci are at centres of explosive oscillation ($\frac{5}{9}$) of orbital loci of Saturn.

θ. Jupiter's mean subsidence-locus is at the nucleal locus of a condensing nebula, of which Saturn represents Laplace's atmospheric limit and Earth is the centre of condensation ; Earth's semi axis major being the unit radius, and Laplace's limit varying as the $\frac{4}{3}$ power of the nucleal radius. Accordances η and θ, which are the closest of all, are especially interesting on account of the variety of indications which they give of the harmonic influence of luminous undulations upon the four great centres of nucleation, condensation, nebulosity and planetary inertia.

The following table shows the closeness of agreement between the harmonic values and Stockwell's.

	Harmonic log.	Stockwell.	Dif. of logs.	Percentage of difference.
α	.7419330	.7418817	.0000513	$\frac{1}{84}$ of one per cent.
β	.7344514	.7345879	.0001365	$\frac{1}{31}$ “ “
γ	.7329514	.7345879	.0016365	$\frac{3}{8}$ “ “
δ	.7150274	.7162369	.0012095	$\frac{2}{7}$ “ “
ε	.7165515	.7162369	.0003146	$\frac{1}{13}$ “ “
ζ	.6974010	.6970763	.0003247	$\frac{1}{13}$ “ “
η	. . . . . .	. . . . . .	.0000000	0 “ “
θ	.7346221	.7345879	.0000342	$\frac{1}{125}$ “ “

See also, Note 334.

331. *Photodynamic Significance of the Temperature of Space.*

Sir John Herschel estimated the absolute temperature of interstellar space as about one-half as great as Earth's mean superficial absolute temperature. If the former temperature is due to stellar radiations, every star must have opposite hemispheres which are exposed to different temperatures, as well as to different gravitating tendencies. The fundamental equation of velocity (Note 321), may be fairly presumed to be universal, so that all stellar rotations may accord with solar rotation in alternately consuming and resuming, at alternate half-rotations, the photodynamic energy of all the superficial particles. At the outer limits of our æthereal system, the æther, if material, should rotate with the stars, so as to radiate and absorb heat like an ordinary atmosphere. A full discussion of conservation of energy in the several stellar systems, requires the consideration of time integrals of various kinds, gravitating, thermal, photic, rotating and revolving. Continual shiftings of position may, perhaps, continually restore to cosmical centres a reactionary *vis viva* which is exactly equivalent to their active radiations.

332. *Hirn's Hypothesis.*

G. A. Hirn (*Comptes Rendus*, Nov. 6, 1882), agrees with Faye in believing that astronomers need an absolute vacuum of matter in order to assure the stability of cosmical movements. He thinks that the doctrine must be discarded which excludes from the physical universe everything but matter and motion, and refers approvingly to Newton's letter to Bentley, implying the necessity of a constant spiritual activity, which cannot be subjected to any materialistic formulation. Seven years ago (*Proc. Am. Phil. Soc.*, xiv, 611, xvi, 302) I published a number of postulates, among which were the following:

"11. Any æthereal medium through which impulses are progressively transmitted, must be material.

"12. Any medium through which impulses are transmitted instantaneously, must be devoid of inertia and, therefore, spiritual."

333. *Laplace's Principle of Periodicity.*

I have elsewhere (*Proc. Am. Phil. Soc.*, xviii, 41–3). given some illustrations of the general principle, which was established by Laplace, that the state of a system of bodies becomes periodic when the effort of primitive conditions of movement has disappeared by the action of resistances. The periodicity of solar rotation shows the action of gravitating resistance against the efforts of luminous undulation. The resistance is just as constant as the radiation, and it would be far to seek any good reason why any provision for perpetuity which may be needful should not accompany every effort and every antagonizing resistance. If spiritual intervention is taken into consideration, its action may be merely directive, because there is a theoretical instant of absolute rest when one oscillation ends and its successor begins, so that there is no material *vis viva* to be overcome.

334. *Two-Fold Nucleation in the Dense-Belt.*

Jupiter's nodal influence (Note 331), co-operating with central condensation in the dense-belt, is shown in the following additional harmonies:

ι. Jupiter's semi-axis major represents Laplace's limit for its own condensing nebula, of which the nucleal limit is the locus of incipient subsidence of Mars.

κ. In tendencies to reverse condensation towards Jupiter, Earth's mean locus of subsidence is $4.1289304\rho_3$ from Jupiter's mean locus. This represents a nucleal radius for which Laplace's limit would be $6.70965\rho_3$, which is near the mean locus of Mars on the opposite side of Sun.

λ. In like reverse condensation, the mean locus of Mars, when in conjunction with Jupiter, represents a nucleal radius for which Laplace's limit would be $5.67968\rho_3$, which is near Mercury's incipient locus of subsidence.

μ. Taking Mercury's mean subsidence locus as final or unit radius, Venus represents a nucleal radius, for which Earth's projectile locus would be Laplace's limit.

The closeness of accordance is shown in the following table :

	Harmonic.	Stockwell.	Difference.	Percentage of difference.
ι	1.75789	1.73648	.02141	$1\frac{1}{4}$ per cent.
κ	1.50685	1.52368	.01683	$1\frac{1}{8}$ " "
λ	.47688	.47680	.00008	$\frac{1}{60}$ " "
μ	.93313	.93226	.00087	$\frac{1}{10}$ " "

For further evidences of nucleal and atmospheric limitations, see *Proc. Am. Phil. Soc.*, xvi, 496–505.

335. *Another Harmonic Estimate of Saturn's Mass.*

It cannot reasonably be expected, among all the different tendencies to harmonic motion, that we can immediately find all which have been operative in any given case. In view of the small amount of work which has been done in this field, such simplicity and closeness of agreement as were shown in Notes 329–31 and 334 are very encouraging, We have already found many evidences of reciprocal or retrograde action in the Neptuno-Uranian belt, of central planetary inertia in the Saturnian belt, and of Jupiter's paramount planetary influence. If we regard all of the dense belt of planets as originally belonging to the great central nucleus, Alexander's harmony, $m_5\,\rho_5^2 \doteq m_6\,\rho_6^2$, may be thus modified :

Jupiter = Sun ÷ 1047.879 = .0009543087
Earth = " ÷ 331776 = .0000030141
Venus = " ÷ 427630 = .0000023385
Mars = " ÷ 3093500 = .0000003233
Mercury = " ÷ 4865751 = .0000002055
Moon = Earth ÷ 81.2 = .0000000371

Amount = Σ_m = .0009602272

Log. Σ_m $\bar{4}.9823740$
" $(\rho_6 \div \rho_5)^2$ .5265244

Log. m_6 $\bar{4}.4558496$
m_6 = .0002856601
$m_0 \div m_6$ = 3500.67

336. *Mean Harmonic Estimate of Saturn's Mass.*

We have seen in Note 326, that in some harmonic approximations the most satisfactory results are reached, as in the foregoing note, by adding satellite or subordinate masses to their primaries, while in other cases it seems best to consider the primary mass alone. The choice of methods, in any instance, may be governed by considerations of static or kinetic equilibrium, instantaneous or progressive action, primitive or subsequent conditions, or other relations which may be unfolded by a more minute study of harmonic astronomy. If we substitute the rotary estimate of Note 313, ($m_0 \div m_3 = 330463$) in Note 335, we get $m_0 \div m_6 = 3500.62$. Combining this value with the two which are given in Note 314, we find an *exact* mean accordance with Bessel's estimate, as follows :

From central primitive nucleation,	3500.62
" " final "	3522.33
" nucleation, condensation, nebulosity and inertia,	3481.86
Arithmetical Mean,	3501.60

337. *Inner Limit of Saturn's Preponderating Influence.*

The two foregoing notes regard all the intra-asteroidal planets as in some sense satellites of Jupiter, which have been made planetary by the superior attraction of the Sun, somewhat as our Moon is both a solar planet and a terrestrial satellite. It may be asked whether Saturn's attraction when in opposition to Jupiter, is not sufficient to invalidate this hypothesis. Jupiter's mass being 3.3415 times as great as Saturn's, the extent of its equal gravitating disturbance is $\sqrt{3.3415} = 1.828$ times as great. Saturn's relative disturbance of intra-Jovian matter is greatest when Saturn is at secular perihelion ($8.734451\rho_3$) and Jupiter is in opposition, at secular aphelion ($5.519271\rho_3$). The limit of equal attraction is then at $\frac{1828}{2828}$ of $14.253722\rho_3 = 9.2134\rho_3$ from Jupiter, or $3.6941\rho_3$ from Sun, on the side towards Saturn, so that it includes all the orbits of the dense planets, and nearly all of the asteroidal belt. This fact gives new meaning to Notes 330 and 334.

338. *More About Comet Wells.*

Notes 295 and 302 illustrate the probable formation of spectral bands by the combination of different harmonic tendencies, as well as the precision of delicate measurements by a skillful observer and accuracy of judgment in estimating the centres of maximum brilliancy. It is, therefore, not unlikely that careful study may discover successive evidences of phyllotactic and other harmonic influences, as was the case in investigating atomic phyllotaxy. If we take the difference between lines α and ε in the Wells' spectrum (Note 295 ; $4769 - 4253 = 516$), the phyllotactic numbers 2, 3, 5, 13, 34, serve in the following sub-multiples ; $\frac{2}{5}$ of $\frac{2}{13}$ of $516 = 31.754$; $3 \times 31.754 = 95.262$; $4 \times 31.754 = 127.015$; $5 \times 31.754 = 158.769$; $\frac{1}{2} \times \frac{1}{5} \times \frac{34}{13}$ of $516 = 134.954$. These numbers give the following accordance :

	Huggins.	Harmonic.	Difference.
α	4769	4769	
β	4634	4634.046	134.954
γ	4507	4507.031	127.015
δ	4412	4411.769	95.262
ε	4253	4253	158.769

339. *Phyllotaxy in the Jovian System.*

The harmonies which are shown in Notes 330 and 334, supplement and help to explain the first four harmonies of Note 29 and the five harmonies of Note 14. Callisto's semi-axis major represents a phyllotactic power of a phyllotactic multiple (3^3), of Jupiter's semi-diameter. The semi-axes major of the three inner satellites are approximately connected with the nebular radius and with one another by the phyllotactic fractions $\frac{2}{5}$ and $\frac{5}{8}$, as follows:

	Harmonic.		Observed.
Nebular radius	38.45	Nebular radius	38.424
$\frac{2}{5}$ of 38.45	15.38	Ganymede	15.3502
$\frac{5}{8}$ of 15.38	9.613	Europa	9.6235
$\frac{5}{8}$ of 9.613	6.008	Io	6.0485

The greatest difference between the phyllotactic and observed loci is $\frac{2}{5}$ of one per cent.

The corresponding orbital times are connected by powers of the phyllotactic number 2.

$2^4 = 16$	Nebular radius	16.0135
$2^2 = 4$	Ganymede	4.0434
$2^1 = 2$	Europa	2.0073
$2^0 = 1$	Io	1.0000

340. *Phyllotaxy of Planetary Mass and Position.*

Peirce's phyllotaxy of orbital times (Note 135), my atomic phyllotaxy (Note 289), and my phyllotaxy of virtual areas (Note 190), encourage a search for phyllotactic relations of planetary mass and distance. Jupiter's mean projectile locus (mean perihelion), is an approximate phyllotactic basis for Saturn's mean locus of subsidence, the rupturing locus of the outer two-planet belt and the mean centre of gravity of the belt:

	Stockwell.	Phyllotactic.
Jupiter	4.978	5
Saturn	10.000	2 × 5
$\frac{1}{2}$ Neptune	15.017	3 × 5
c. g. Uranus and Neptune	25.031	5 × 5

If Saturn's mean perihelion were in the same longitude as that of the outer belt, the phyllotactic sum of their disturbing forces (2 + 5) would become an important limit of oscillatory inertia. Simple phyllotactic combinations of this sum with phyllotactic powers of 2, 3, and 5 give the following mass-approximations:

	Computed.	Phyllotactic.
Sun ÷ Jupiter	1047.879	$1050 = (2+5)\ (2\times5)\ (3\times5)$
Sun ÷ Saturn	3501.6	$3500 = (2+5)\ (2\times5)^2\ (5)$
Sun ÷ Uran. and Nep.	10433	$10500 = (2+5)\ (2\times5)^2\ (3\times5)$
Sun ÷ Earth	330463	$330750 = (2+5)^2\ (2\times5)\ (3\times5)^2(3)$
Sun ÷ Venus	427240	$428400 = (2+5)\ (2^3\times5)\ (3^2\times5)\ (34)$
Sun ÷ Mars	3093500	$3094000 = (2+5)\ (2\times5)^3\ (13\times34)$
Sun ÷ Mercury	4865751	$4873050 = (2+5)^2\ (3\times5)^2\ (13\times34)$

The greatest deviation is less than $\frac{7}{10}$ of one per cent.

341. *Centripetal Harmonies of Planetary Mass and Position.*

If we begin with the outer two-planet belt, we find evidence of the following successive influences:

a. Rotary *vis viva*, ($m\rho^2 \div 2$). (1). If we call the sum of the masses of Neptune and Uranus $m_{(7)} = m_7 + m_8$, we find that its influence of rotary perturbation introduces both the same and the diametrically opposite mean perihelion longitudes of Saturn, provided that $\rho_{(6)}$ and $\rho_{(7)}$ represent, respectively, the incipient loci of subsidence of Saturn and Uranus; $m_{(7)}\ (\rho^2_{(7)} - \rho^2_{(6)}) = m_6\rho_{(6)}^2$. (2). If we call the sum of the masses of Jupiter and the dense belt, $m_{(5)} = m_5 + m_4 + m_3 + m_2 + m_1$, we find that its mean influence of rotary perturbation is the same as that of Saturn; $m_{(5)}\rho_5^2 = m_6\rho_6^2$.

β. Rotary momentum. The interior mass of the three primitive masses, $m_{(5)}$, was so divided that Sun's semi-diameter became the rupturing locus for the principal centre of gravity of the system (c. g. of m_0 and m_5). Designating Jupiter's radius vector at secular perihelion by $\rho_{(5)}$, we find, $m_0\rho_0 = m_5\rho_{(5)}$.

γ. Photic time-integral. Sun's mass and density are so harmoniously adjusted that the oscillations of solar rotation indicate the actions and reactions of a wave-velocity which is equivalent to the velocity of light (Notes 17, etc.).

δ. Secondary time-integrals. The solar superficial gravitating acceleration, which is determined by the photic time-integral, determines in its turn the velocity of circular-orbital oscillation ($\sqrt{gr}$) at all distances from Sun's centre. The velocity at Sun's surface gives Jupiter's time-integral: the velocity at the mean centre of gravity of the system gives Earth's time-integral.

ε. The photic time-integral (*γ*), the probability that Sun's density is harmonically determined by the density of hydrogen, and the equality of æthereal and solar mass which is implied by their equality of action and reaction, give the proportion at Sun's surface,

$$\text{Modulus}^3 : \rho^3_0 :: \text{density of hydrogen} : \text{æthereal density}.$$

342. *Secondary Harmonies of Planetary Mass and Position.*

The data of the foregoing note are sufficient for approximate determinations of the respective masses at the chief centres of nucleation, condensation, nebulosity, and rotary planetary inertia, (Sun, Earth, Jupiter and Saturn). The division of the outer two-planet belt, and the separation of Venus from the primitive interior belt were determined by simple relations of vector-radii, which may be regarded as indicative either of photodynamic time or photodynamic *vis viva.*

ζ. The radii which determined the aphelion and perihelion masses of the outer belt were, respectively, the aphelion and perihelion loci, or the loci of incipient subsidence and incipient projection, at the inner limit of the belt (Note 315).

η. The radii which determined the relative masses of Earth and Venus were, respectively, the mean radius-vector and the locus of incipient subsidence of the respective planets (Note 313).

343. *Centripetal Approximations*

If we take the phyllotactic estimates of Mercury and Mars (Note 340), with the gravitating or centripetal estimates of the other planets, and of solar and æthereal density (Notes 341-2), we find the following approximations, which may be compared with those of Notes 325 and 328 :

	Harmonic.	Computed.	Difference.
Sun ÷ Mercury,	4873050	4865751	$\frac{3}{20}$ of one per cent.
Sun ÷ Venus,	426721	427240	$\frac{1}{8}$ " "
Sun ÷ Earth,	330463	331776	$\frac{2}{5}$ " "
Sun ÷ Mars,	3094000	3093500	$\frac{1}{62}$ " "
Sun ÷ Jupiter,	1047.879	1047.879	
Sun ÷ Saturn,	3500.69	3501.6	$\frac{1}{38}$ " "
Sun ÷ Uranus,	22759	22600	$\frac{7}{10}$ " "
Sun ÷ Neptune,	19467	19380	$\frac{13}{29}$ ". "

Density of Sun ÷ Earth .25492	Log. = $\bar{1}.4064086$
Density of Æther ÷ Hydrogen 106,939,960.000,000,000	17.0291400
Solar Modulus of light, $474657\rho_0 = 2213.37\rho_3$	3.3450539
Solar Rotation, 25.5064 days	1.4166487
Orbital time at ρ_0, 10049 seconds	4.0021223
Sun's semi-diameter, ρ_0, 432089 miles	5.6355735
Earth's semi-axis major, ρ_3, 92,661.550 miles	7.9668996

344. *Laplace, Herschel and Fourier.*

Laplace's statement of the nebular hypothesis has been generally thought to imply that the planets and satellites were thrown off by the centrifugal force of contracting nuclei. Many objections have been found to this hypothesis, of which the moons of Mars furnish a striking example. Herschel's theory of subsidence, by recognizing the equality of action and reaction, removed these objections, provided for the recognition of cometary and meteoric influences, and made the moons of Mars, as I have shown (*Proc. Am. Phil. Soc.*, xvii, 302), an unexpected confirmation of his views. Fourier's discussions of elasticity and cyclical motion, in a line of research to which American investigators have made important contributions (see *op. cit.*, xvi, 298–302), showed that all cyclical movements are *quasi*-elastic and may be represented by simple combinations of elastic formulæ, and thus paved the way for a wide extension of the theory of harmonic motion. The three foregoing notes show a combination of simultaneous and continuous activities, which it would be difficult, if not impossible, to explain by Laplace's theory. They are all, however, in full accordance with the views of Herschel and Fourier, and they indicate that the photic æther may still be regarded as nebulous.

345. *Photic Loci of Earth and Saturn.*

Note 341 suggests the influence of linear oscillation in subsiding particles. Neptune's locus of incipient subsidence ($30.47\rho_3$) became, by the relative slowness of its motion, a point of virtual suspension. Saturn's locus of incipient subsidence ($10.343\rho_3$) which was near its centre of oscillation ($10.16\rho_3$), was the origin of the belt of mean planetary inertia. While the Neptuno-Uranian and the Jupiter-Telluric belts were yet undivided, the theoretical period of rotation was $(30.46955 \times 214.45)^2 \times 25.5064$dy $=$ 3050950.7 years. The fundamental photodynamic equation (Note 321), with the equality of action and reaction, fixed the chief centre of condensation at a locus which is in simple photic relations with the solar nucleus, the photic radius of rotation and the centre of planetary rotating inertia. For the mean proportional between the mean locus of incipient planetary subsidence ($10.343253\rho_3$) and Earth's semi-axis major is $3.2161\rho_3 = 689.69\rho_0$. If we call this the photic radius, or the locus of luminous equatorial velocity for a sphere which would have orbital velocity at Sun's surface, Earth's semi-axis major should be $[31558149 \div (2\pi \times 497.827 \times 689.69)]^2\rho_0 = 213.99\rho_0$, which is within $\frac{4}{19}$ of one per cent. of the British Nautical Almanac estimate ($214.45\rho_0$).

346. *Mass-Relations of Earth and Saturn.*

The relative masses, as well as the relative positions, of the chief centres of condensation and of planetary inertia, show simple harmonic accordances with the energies of æthereal rotation and reacting inertia; Earth's locus of incipient projection ($.932265\rho_3$), bearing the same ratio to Saturn's mean locus of projection ($9.077645\rho_3$), as the square root of Earth's mass bears to the square root of Saturn's mass, thus indicating an exact equivalent between the moment of rotation and the inertia of mass. This gives $331988m_3 = m_0$; $\rho_3 = 92{,}805{,}400$ miles. The mass-value differs by less than $\frac{1}{33}$ of one per cent. from the value which was adduced from the relative inertia of Earth and Jupiter (Note 152), and by less than $\frac{1}{15}$ of one per cent. from the value which was deduced from centres of oscillation (Notes 5, 23).

347. *Phyllotaxy of Orbital Periods.*

The closeness of the phyllotactic mass-harmonies (Note 340), may be more strikingly shown by observing the discrepancies in Peirce's approximations to the orbital periods of the primary planets, which seem to have been the first extensions of the phyllotactic theory beyond the vegetable world :

	Phyllotactic.		Observed.	Difference.
		Neptune	60126.72	
$\frac{1}{2}$ Neptune	30063.36	Uranus	30686.82	$2\frac{1}{14}$ per cent.
$\frac{1}{3}$ Uranus	10228.94	Saturn	10759.22	$5\frac{2}{11}$ "
$\frac{2}{5}$ Saturn	4303.69	Jupiter	4332.58	$\frac{2}{3}$ "
$\frac{2}{5}$ Jupiter	1733.03	Asteroid 139	1723.37	$\frac{5}{9}$ "
$\frac{2}{5}$ Asteroid 139	689.35	Mars	686.98	$\frac{1}{3}$ "
$\frac{1}{2}$ Mars	343.49	Earth	365.26	$6\frac{1}{3}$ "
$\frac{8}{13}$ Earth	224.78	Venus	224.70	$\frac{1}{28}$ "
$\frac{2}{5}$ Venus	89.88	Mercury	87.97	$2\frac{1}{8}$ "

The greatest deviation is more than nine times as great, and the mean deviation is more than ten times as great as in Note 340.

348. *Photic Relations of Earth, Jupiter, and Asteroid 139.*

In view of the many evidences of the important influence of Jupiter upon planetary harmonies, the following proportion becomes suggestive :

$$t_a : t_\beta :: \rho_\lambda : \rho_0$$

The second theoretical phyllotactic reduction of Jupiter's orbital period, $\frac{2}{3}$ Asteroid 139, is represented by t_a ; Earth's day, by t_β ; the photic radius (Note 345), by ρ_λ ; Sun's semi-diameter, by ρ_0. The value of ρ_3, as deduced from this proportion, is $214.2\rho_0$, which is about $\frac{2}{17}$ of one per cent. less than the British Nautical Almanac estimate. This is only $\frac{1}{156}$ as great as the mean accidental deviation (Note 288).

349. *Modifications of Harmonic Planetary Masses.*

The approximations of Note 342 are more closely connected than those of Note 328, and indicate a simpler bond of harmony. Among the various harmonic influences which may be presumed to have modified planetary masses and to be represented in their harmonic motions, are the following : (1). The fundamental velocity of Note 321, which was first indicated by my barometric investigations (*Proc. Am. Phil. Soc.*, ix, 283–8). (2). Centres of linear, spherical and explosive oscillation (*Ib.*, xii, 392–4, 411–7 ; *et al.*). (3). The acquisition of nebula-rupturing velocities, by subsidence from nr to $\frac{nr}{n+1}$ (*Ib.* xii, 518–22). (4). Tendency to rupture in the periphery of a stationary nebula, at $2r \div (3 - \sqrt{8})$ (*Ib.* xvii, 98–99). (5). Belt-forming tendencies, through subsidence, at $\frac{2r}{3}$ (*Ib.*, xvii, 100*). (6). The ratio of the circumference of a circle to its diameter (*Ib.*, xiii, 140–1, xiv, 609–12, *et al.*). (7). Time integrals, rotation-waves, harmonic vibrations, polar forces, etc. (*Ib.* xiv, 141–7). (8). Laplace's limit, and its variation as the $\frac{4}{3}$ power of the nucleal radius (*Ib.*, xiv, 612, 622, 652, *et al.*). (9). Constancy of pressure and constancy of volume (*Ib.*, xiv, 651). (10). Instantaneous velocity, implying spiritual influence (*Ib.*, xiv, 611; xvi, 302, *et al.*). (11). Comparative variations of distance and density, in elastic media (*Ib.*, xvii, 109–12, *et al.*).

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* Instead of "minor axis of $\sqrt{8r}$" *read* "minor axis of $\sqrt{2r}$."

350. *Relation of Inertia to Time and Force of Oscillation.*

M. Lipschitz, in a letter to M. Hermite (*Comptes Rendus*, xcv, 1141), discusses some points which have an important bearing on my fundamental equation (Note 321), and on time-integrals in general. Supposing a heavy body to turn freely about a horizontal axis, he considers two kinds of movement. In the first, the angular velocity becomes 0 at θ_0; in the second, at $\pi - \theta_0$. The times in the two movements may be expressed by elliptic integrals of the first order, with complementary moduli. The corresponding integrals of the second order represent Hamilton's *accumulated vis viva*, or the integral of which the element is equivalent to the sum of all the living forces of the system multiplied by the element of the time. The result of the discussion, which he considers remarkable, gives an equation of oscillating times and accumulated *vis viva*, for the two kinds of movement, which depends solely on the moment of inertia of the body.

351. *Motion of Sun-Spots in Latitude.*

Spœrer, in a letter to Faye (*Comptes Rendus*, xcv, 1110), reports observations upon the movement of Sun-spots in latitude. Arranging the observations of twenty years (1861–80) in 5° belts, he finds a slight excess of movement towards the equator between the parallels of 5° and 10°, and a slight excess towards the poles between the parallels of 20° and 25°. Carrington and de Rico found a predominance towards the equator between 0° and 15°, and towards the poles in higher latitudes, but the indications were so slight that Carrington attached no importance to them. Faye regards these results as fatal to the theory of Siemens, for if the Sun is fed by the subsidence of matter towards the poles, he thinks that the equatorial centrifugal force should produce a constant tendency of spots towards the equator. He also calls attention to the fact that the centripetal force at Sun's equatorial surface $\left(\frac{gr}{3_0} \div v^2_{\text{rot}}\right)$ is about 48000 times as great as the centrifugal, and he attributes the equatorial increase in apparent velocity of rotation to the continual convection-currents between the photosphere and the interior of the Sun.

352. *Photodynamic Centrifugal Energy.*

At the very outset of my planetary investigations I called attention to the accelerating effects of "subsidence," and Hall's discovery of the moons of Mars strengthened my conviction that such acceleration was the *vera causa* of Sun's equatorial acceleration. Jupiter's influence upon harmonic masses and positions (Notes 313, etc.), and the close approximation of the photic radius (Note 345) to Jupiter's projectile centre of linear oscillation, show that there are activities, at various distances from the Sun, which should be considered in discussing the conservation of solar energy. The centrifugal force to which Siemens refers is by no means limited to Sun's surface ; at Laplace's limit ($36.36r_0$), at the photic radius ($689r_0$), and at the solar modulus of light (689^2r_0), there are important rotating and consequent centrifugal tendencies which have been almost wholly overlooked. Darwin's discussions of terrestrial "viscosity" furnish many suggestive hints for an investigation which, as I fully believe, will help greatly to extend Laplace's views of universal stability. No one, probably, would think of limiting the centrifugal force of terrestrial rotation to Earth's surface, nor even to its atmospheric modulus ; there is great likelihood that an appreciable atmosphere may extend even beyond Laplace's limit ($6.6r_3$), all portions within that limit rotating synchronously with Earth, while all portions beyond the limit are subject to combined influences of rotation and revolution. Sun's æthereal modulus extends to more than 73 times Neptune's semi-axis major, and if we suppose that to be the limit of æthereal centrifugal tendency, we have an available velocity which is 689 times as great as the velocity of light, If we suppose, still further, that Laplace's velocity of gravitating action, more than $100,000,000v_\lambda$ (*Mec. Celeste*, X, vii, 22), represents an actual physical velocity, we have a radius of rotating influence which extends from the Sun as a centre to more than 13000 times the distance of α Centauri.

353. *Motion in Perfect Fluids.*

Siemens calls attention (*Comptes Rendus*, xcv, 1040), to the results of Froude's Torquay experiments, which showed that a submerged body, moving with uniform velocity in a perfect fluid, will meet no resistance whatever. By "a perfect fluid" is meant a fluid free from viscosity or *quasi* solidity, and in which no friction is caused by the slipping of its particles either over one another or over the surface of the body. If there are any such fluids, the luminiferous æther is doubtless one. Ferrel's investigations have shown that the centrifugal force of rotation would draw it entirely away from the poles, so that more viscous fluids, such as our atmosphere, would serve, as Siemens says, as lubricators, to supply temporary vacua which would otherwise result from the slight lateral elastic oscillations of the æther. These considerations, as well as those of the foregoing note, open a new field for analytical research, which must be thoroughly explored before final judgment can be passed upon questions pertaining to the conservation of solar energy, the stability of the physical universe, and the reproach of thermodynamics.

354. *Centripetal Transformation of Radiations.*

When particles or bodies are moving in circular orbits, under the influence of central forces, the centripetal and centrifugal forces are in equilibrium; in parabolic orbits, the centripetal *vis viva* is twice as great as the centrifugal on approaching the centre, and one-half as great on receding from the centre ; in elliptical orbits, the ratio of the living forces varies inversely as the ratio of the radius-vector to the semi-axis major. In actual orbital motions, the alternate oscillations between the apsides are equal, but in opposite directions. This must be true of the æther, as well as of planets and satellites, if the æther has any orbital motion, and reasoning from analogy we might fairly suppose that it is true of æthereal waves. What becomes of the heat which is supposed to be absorbed by the æther? Does it increase the mean distance of the æthereal particles, does it maintain an ever increasing amount of æthereal undulation, or is it resolved into some form of gravitating or other centripetal activity, which furnishes conclusive evidence of the universality of the law that "action and reaction are equal and in opposite directions?" A single fact is worth more than a million theories, however plausible they may be. The second law of thermodynamics is purely theoretical, inasmuch as it tries to account for activities which are beyond the reach of experimental investigation. The fundamental equality of Note 321 is a significant and far-reaching FACT, which illustrates Laplace's principle of periodicity (Note 333), and bears satisfactory witness to the continuance of activities which have hitherto been the reproach of thermodynamics.

355. *Primitive Photodynamic Locus of Neptune.*

The combined influence of the tendencies to rotation and revolution (Notes 348, 352, etc.), is shown in the outer limits, as well as at the centre of the planetary system. The outer extremity of the photic radius (Note 345), has an oscillatory trajectory which is $(\pi v_\lambda \div v_0)$ times as great as that of ρ_0. Its rotatory *vis viva*, and consequently, its radius of relative projection, is $(\pi v_\lambda \div v_0)^2$ times as great, and the orbital period of this projectile radius is $(\pi v_\lambda \div v_0)^3 \times 2\pi \sqrt{(r_0 \div g_0)}$. Jupiter's secular eccentricity, according to Stockwell, is .0608274. This gives, for the linear centre of oscillation of its locus of incipient subsidence, .0405516, and for the solar radius vector of that centre, 1.0405516. If we take a like projection of Neptune's locus of incipient subsidence ($1.0405516 \times 30.46955 = 31.70514$) as an original nucleal radius (ρ_ν) for which Laplace's limit (ρ_λ) was $(\pi v_\lambda \div v_0)^2 \rho_0$, we find $\rho_3 = (\pi^2 v_\lambda \rho_3 \div v_3 \rho_\nu)^{\frac{2}{3}} \rho_0$; $v_\lambda \div v_3 =$ 31558149 sec. $\div$ ($2\pi \times 497.827$ sec.) $= 10089.116$; $\rho_3 = 214.461\ \rho_0$; $\rho_\nu = 6799.52\ \rho_0$; $\rho_\lambda = 4684434\ \rho_0$.

356. *Primitive Photodynamic Locus of Saturn.*

The value of Sun's apparent semi-diameter as deduced from the foregoing note is 206264.″806247 ÷ 214.461 = 961.″78, the British Nautical Almanac estimate being 961.″82. A mean proportional between Sun's semi-diameter and ρ_λ ($2164.36\ \rho_0 = 10.09206\ \rho_3$) is within less than one per cent. of Saturn's mean subsidence locus ($10.000059\ \rho_3$). The photic radius ($\rho_\phi = \rho_0 \, v_\lambda \div v_0 = 688.936 \, \rho_0$) is a mean proportional between Earth's semi axis major and Saturn's incipient subsidence locus ($2218.23 \, \rho_0 = 10.343253 \, \rho_3$) within less than $\frac{1}{8}$ of one per cent. A mean proportional between ρ_ϕ and ρ_ν is also a mean proportional between ρ_0 and ρ_λ. Hence we see that Sun's radius, Earth's radius-vector, the photic radius, as well as the original nucleal and limiting radii of the system, are all represented through their harmonic influences upon the belt of mean planetary inertia.

357. *Stellar Relations of Primitive Photodynamic Loci.*

In whatever way we may regard these many indications of harmonic influence upon planetary positions and orbital periods, whether as furnishing evidence of early nebular condensation or of nebular activities which still continue, we can hardly believe that they are confined to our immediate system. The nearest companion system being that of *α Centauri*, we need feel no surprise at finding that ρ_ν is a mean proportional between Sun's radius and the distance of *α Centauri*, and ρ_λ is a mean proportional between the solar modulus of light and the distance of *α Centauri*. The distance which is thus indicated differs by less than $\frac{1}{3}$ of one per cent. from the one which was deduced from the corona line and the masses of Earth and Jupiter (Note 46). The photic radius is, of course, a mean proportional between Sun's radius and the solar modulus of light.

358. *Photodynamic Relations of the Neptunian System.*

Stockwell (*Wash. Obs.*, for 1873, App. I), deduced two values for the quotient of Sun's mass by Neptune's mass, viz.: 19700 from perturbations of Uranus, and 19380 ± 70 from Neptune's satellite. The former value may, perhaps, indicate the mass of the planet; the latter, the mass of the Neptunian system, including the satellite which has already been discovered, together with any others which may be yet unknown, and one or more possible remote planets. The orbital period of the primitive projectile radius (Note 355) is 19613.1 times Neptune's orbital period. Designating these periods by t_0 and t_8, respectively, we have the approximate harmonic proportion,

$$t_0 : t_8 :: 19613.1 : 1 :: m_0 : m_8.$$

This value is intermediate between Stockwell's two estimates, differing but $\frac{3}{8}$ of one per cent. from their mean, but $1\frac{1}{5}$ per cent. from the smaller and but $\frac{4}{9}$ of one per cent. from the larger estimate. As the proportion is based upon time-integrals which must be operative, this closeness of accordances is interesting.

359. *Phyllotactic Relations of Earth and Neptune.*

To the harmonic relations which I have already pointed out, between the planetary masses at the centre of incipient subsidence (Neptune) and at the chief centre of nucleation, may be added a very simple phyllotactic relation, which is shown by the proportion,

$$m_3 : m_8 :: 2 : 34.$$

If we take the mass-estimate of Note 313, $m_0 \div m_3 = 330463$, this proportion gives $m_0 \div m_8 = 19439$, which is, within the limits of probable error, in accordance with Stockwell's second estimate. The interest of this harmony is increased by the fact that the ratio of Earth's equatorial velocity of rotation is to the limiting value of $\sqrt{g_3 r_3}$ in the same phyllotactic ratio of 2 to 34.

360. *Harmonic Relations of Saturn, Mars, and the Telluric System.*

The harmonic actions and reactions among the masses at the centre of planetary inertia (Saturn), the centre of incipient subsidence for the belt of greatest condensation (Mars), and the central system in the belt of greatest condensation (Earth and Moon), is shown by the proportion

$$m_6 : \pi \, m_{(3)} : : \pi \, m_{(3)} : m_4.$$

Taking Bessel's estimate, $m_0 \div m_6 = 3501.6$, with the rotary estimates of Notes 313 and 316, $m_0 \div m_3 = 330463$, $m_3 \div \mu = 81.08$, this proportion gives $m_0 \div m_4 = 3083416$, which differs by less than $\frac{1}{4}$ of one per cent. from Hall's estimate. These repeated harmonic relations of mass seem to show that every planet represents some special central tendency, and when that tendency is found, the harmonic calculus will furnish estimates which are generally closer than those which have been reached by the ordinary astronomical methods. If this is the case with the first approximations, we may well hope that a due regard to secondary and subordinate harmonies will give results of a very satisfactory character. In the present instance, if we regard Hall's estimate as correct, and deduce the value of Earth's mass, we find $m_0 \div m_3 = 331003$, which is within the limits of probable error.

361. *Synoptic Table.*

The six foregoing notes are, in some respects, more comprehensive in their harmonic indications than any that have preceded them. I therefore give the following comparative table :

	Harmonic Logarithms.	Anti-logs.	$n \, \rho_3$
ρ_3	2.3313488	214.461	1.
ρ_ϕ	2.8381787	688.936	3.2124
ρ_ι	3.3353286	2164.356	10.0921
ρ_ν	3.8324785	6799.523	31.7051
M	5.6763574	474632.	2213.1381
ρ_λ	6.6706572	4684435.	21842.8
a Cent.	7.6649570	46233521.	215579.8
$v_0 \div v_r$	2.3410288	219.295	
t_0	4.0020883	10048.2 sec.	
t_r at ρ_0	6.3431171	2203520.3 sec.	
t_r at ρ_0	1.4066034	25.504 days.	
$\delta_0 \div \delta_3$	$\bar{1}.4064550$	25495	

362. *The Terrestrial Series.*

The above table introduces two geometrical series; the first having the ratio π, and having for one of its terms a solar radius-vector for Earth, similar to the one for Jupiter in Note 355 $(1 + \frac{2}{3} \varepsilon_3 = 1.02258)$.

	Harmonic.		Observed.
a	.32548	Mercury, mean perihelion,	.31873
$\pi\ a$	1.02254	Earth, l. c. o. of sec. ecc'y,	1.02258
$\pi^2 a$	3.21240	Photic radius, ρ_ϕ,	3.21240
$\pi^3 a$	10.09201	Saturn, mean aphelion,	10.00006
$\pi^4 a$	31.70514	Neptune, ρ_ν,	31.70514
$\pi^5 a$	99.60465	Forbes, I, Note 32,	100.
$\pi^6 a$	312.91727	Forbes, II, Note 32,	300.

This series includes the inner and outer principal planets, the centers of planetary inertia and of maximum condensation, the photic radius, and the two supra-Neptunian belts of cometary aphelia. The planetary loci are those of my first anticipatory series (*Proc. Amer. Phil. Soc.*, xiii, 140), with such modifications as represent the photic radius and the linear centers of oscillation of Earth and Jupiter. Each of the two-planet belts is indicated, and the photic radius precisely marks the locus of Asteroid 108. It also differs by less than $\frac{1}{8}$ of one per cent. from a mean proportional between Earth's semi-axis major and Saturn's locus of incipient subsidence $(3.21609\ \rho_3)$.

363. *The Stellar-Photic Series.*

The second geometrical series of Notes 355–61, has the ratio π^2 and has, for two of its terms, a stellar locus and the solar modulus of light.

	Harmonic.		Observed.
β	.00239	.5135 Sun's semi-diameter,	.00239
$\pi^2 \beta$	.02363	5.0683 Sun's semi-diameter,	.02363
$\pi^4 \beta$	.02324	$\frac{1}{2}$ Mercury's sec. aph.,	.23840
$\pi^6 \beta$	2.30202	Mean prop. Jupiter and Earth,	2.28096
$\pi^8 \beta$	22.72004	$\frac{3}{4}$ Neptune's mean aph.,	22.75153
$\pi^{10} \beta$	224.2378		. . .
$\pi^{12} \beta$	2213.1381	Solar modulus of light,	2213.1381
$\pi^{14} \beta$	21842.804	Photic projectile radius,	21842.804
$\pi^{16} \beta$	215579.86	*a Centauri*,	215579.86

The planetary indications are not quite so satisfactory as in the foregoing series, but the deviations are of the same order of magnitude as planetary eccentricities. Neptune's mean subsidence locus indicates a solar nebular density corresponding to Laplace's limit, for a rotating nucleus with a semi-diameter equivalent to $\pi_8 \beta$. Mercury's primitive subsidence-locus indicates a degree of "viscosity" which would give a rupturing tendency at a mean proportionate locus between Sun's viscous rupturing locus and $\pi_8 \beta$. The mean proportional between these two loci is also a mean proportional between Earth's primitive subsidence-locus and Jupiter's mean projectile-locus. The deviations from exact accordance, according to

Stockwell, are respectively, $\frac{1}{7}$ of one per cent., $\frac{1}{46}$ of one per cent. and $\frac{2}{13}$ of one per cent. The three terms which indicate mere photodynamic progression show an exact accordance; but there is a range of uncertainty which is of the same order of magnitude as planetary eccentricities, with regard to the exactness with which the third of those terms represents the locus of α *Centauri*. The harmonic term preceding the solar modulus is 7.466 times Neptune's semi-axis major. It has no obvious known representative, but future researches or discoveries may make it significant. The Terrestrial and the Stellar-Photic series are connected by the proportion:

$$\alpha : \beta : : \pi^{10} \rho_0 : \rho_\phi : : \pi^{10} v_0 : v_\lambda .$$

These several relations confirm the views which were expressed in Note 262.

364. *Photodynamic Subsidence-Relation of Earth and Jupiter.*

The photodynamic projections of β from Sun's rupturing locus, of the chief centre of gravity (Sun and Jupiter) from Sun's surface, of the centre of the dense belt from the chief centre of condensation, and of ρ_ν from Neptune's locus of incipient subsidence, seem partly to account for the photodynamic gravitating relations of Earth's day and year. The radius vector of the viscous rupturing locus of Jupiter's incipient subsidence (Note 355) is 1.0304137. If $t_3 = 1$ year, we have, very nearly if not exactly, the equations:

$$\begin{aligned} g_3\, t_3 &= 1.0304137\ v_\lambda . \\ v_\lambda &= 186125.8 \text{ miles.} \\ \rho_3 &= 92{,}659{,}000 \text{ miles.} \\ m_0 &= 330{,}419\ m_3 . \end{aligned}$$

365. *Conservative Momentum of Vis Viva.*

Whether we accept or reject the hypothesis of Lesage, as a literal explanation of gravitating action, it may serve as a convenient concept for representing activities which are obviously incessant. There are constant centripetal tendencies towards the Sun, as well as constant radiations from the Sun, each varying inversely as the square of the distance, and each subject to the law of equality between action and reaction. Lesage supposed that they were opposite phases of a single energy, and his views are favored by the law of parsimony. If we reject them altogether, our perplexity is doubled, for we have two reactions to account for, instead of one. Even Newton, Peirce and Helmholtz; the first, in his hypothesis of an "æthereal spirit," the others in seeking an equivalent between solar radiation and solar contraction; were guided, though less directly, by the law of action and reaction. In circular orbital motion, centripetal gravitation continually deflects the tangential path, so as to make it π times as long as the radial path before the tangential oscillation reverses its direction. The influence of momentum in such a change is represented by the terrestrial series (Note 362); the influence of *vis viva*, in the stellar-photic series (Note 363); the influence of both, in the fundamental equality (Note 321). If there is neither waste nor accumulation of energy, and if there is a material æther, the hypothesis that the centrifugal action of every æthereal radiation is followed by an equal and opposite centripetal reaction, and *vice versa,* is justified by all the known phenomena of the heavenly bodies.

366. *Dynamics and Kinematics.*

William B. Taylor delivered an address on "Physics and Occult Qualities," before the Philosophical Society of Washington, Dec. 2, 1882, on retiring from the Presidency of the Society. He discusses with great skill and lucidity, the comparative views of the kinematists who hope in time to resolve all physical enigmas by molecular processes, and of the dynamists who, "having searched in vain for any plausible co-ordination of the indisputable facts of cohesion [and other material phenomena] with an intelligible mechanical agency, simply acquiesce in the result, and without invoking the unknown or the irrelevant, accept this established property as ultimate and inexplicable." In one paragraph (p. 30) he says: "Without the indestructible—unwasting—tensions of molecular attraction and repulsion, it lies beyond the scope of human ingenuity to devise or imagine a conservative system," thus corroborating views which I have been advocating for twenty years. In another (p. 48), he seems to be somewhat self-contradictory, in saying: "*Under the present system of dynamic law,* it is certain that as radiating and cooling bodies,

'The Stars shall fade away, the Sun himself
Grow dim with age, and nature sink in years.'

Nor is there known to science any natural process whereby this cosmic doom may be either averted or repaired by ulterior reversal." This is true of kinematics, but dynamic law positing behind itself "an Infinite LAWGIVER," need give no thought to kinematic perplexities and paradoxes. Force "is attended with no expenditure and is capable of no exhaustion" (p. 30). In his reference (p. 27) to the experiments of Guthrie and Bjerknes, on attractions or repulsions by mechanical vibration, he has overlooked my own experiments, which were published more than six years before Guthrie's (*Proc. Amer. Phil. Soc.*, ix, 359; x, 151–66). In his antagonism of the doctrine of "unity of force" (p. 45), he makes no reference to the identification of velocity, in the most important known manifestations of photic, electrical, gravitating and thermal activity, as shown in the fundamental equality (Note 321).

367. *Anticyclonic Storms.*

Loomis, in his 18th Contribution to Meteorolgy (*Am. Jour. Sci.*, Jan., 1881), gives many illustrations of the frequency of anticyclonic storms, to which I called attention in 1871 (*Proc. Am. Phil. Soc.*, xii, 40). My views were afterwards adopted in the Signal Service "Suggestions as to the practical uses of Meteorological Reports and Weather Maps," in magazine and newspaper articles by S. S. observers, and in reports of the Chief Signal Officer. Prof. Loomis is, perhaps, somewhat unconsciously biased by a still lurking prejudice in favor of Redfield's views, which disposes him to trace all rainfalls to "a cyclonic movement of the winds about the rain area." As soon as the rain begins to fall, there must undoubtedly be a local cyclonism, as I stated (*loc. cit.*, 7); but a careful study of weather-maps, especially in winter storms and in cases of failing forecasts, satisfies me that the *origin* of storms is as much anticyclonic as cyclonic. The frequent instances of snows in a "high" area, with simultaneous rains in a "low" area, are very instructive. Ferrel's researches show that cyclonism and anticyclonism must be companions. It is, therefore, hardly right to regard either as peculiarly storm-breeding. The *vera causa* is a blending of moist and cold currents. When the precipitation begins in a high area, the initial currents are anticyclonic; when in a low area, cyclonic. Ferrel's middle-latitude ridge of high barometer also explains the anticyclonism of our Southern States, to which Loomis refers.

368. "*Central Forces and the Conservation of Energy.*"

Mr. Walter R. Browne (*Phil. Mag.*, Jan. 1883), confirms some of the views of central force which have guided my own researches, and which are embodied in Taylor's retiring address (Note 366). He shows that the conservation of energy requires, and results from the equation

$$\int_{a}^{a+b} \mathrm{F}\, dx = \int_{a+b}^{a} \mathrm{F}\, dx\,;$$

in which two particles, A and B, are alternately receding and approaching between the distances a and $a + b$; and that F can only be a function of r; "in other words, the force with which A acts upon B always tends towards A, and varies, if it varies at all, according to the distance from A only. But this is the definition of a central force." He also refers to his paper "On Action at a distance" (*Phys. Soc.*, 1881; *Phil.. Mag.*, Dec., 1880), in which he showed that it is "impossible to explain certain elementary facts of physics without the hypothesis of action at a distance." He deduces from the kinetic theory of gases, the conclusion that the collision "occasions the instantaneous development of a strictly infinite force." In 1876, I showed that "if the theory of Boscovich were true, at the centre, where $\rho = 0$, v_ρ would be infinite" (*Proc. Amer. Phil. Soc.*, xvi, 304). These conclusions, as well as Laplace's doctrine of the instantaneous action of gravity (*op. cit.* p. 302), are inexplicable by any hypothesis which does not either recognize spiritual activity or spiritualize its definition of matter.

369. *Mean Molecular Excursions.*

In discussing the kinetic interpretation of the law of gases, Taylor cites (*Address* p. 17) the application of the calculus of probabilities, by which Clausius inferred "that of the whole number of free molecular excursions in a given time (in any large enclosure), those having less than the mean length will be 0.6321, or nearly double the number of those having the mean length or exceeding it. The simplicity of thermodynamic relations in central force (*Proc. Amer. Phil. Soc.*, xiv, 651), suggests an equally simple means of estimating the proportionate number of mean excursions. Peirce's views respecting the *vis viva* of rotation (see *Proc. Amer. Phil. Soc.*, xvi, 300), involve the consideration of the mean moment of inertia, which is represented by $\frac{2\,r^2}{5}$, the momentum being represented by $r\,\sqrt{\tfrac{1}{4}} =$ .632455 r, which differs from the estimate of Clausius by less than $\frac{1}{17}$ of one per cent.

370. *Cosmical Influence of Rotary Inertia.*

We may naturally suppose that, among the many harmonic influences which have combined in fixing the relative positions of the several planets, rotary inertia should be represented Among the evidences which strengthen such a supposition, are the following:

2.5 Mercury, sec. per.,	.7435	Venus, mean aph.,	.7489
1.5 Mercury, mean per.,	.4781	Mercury, s. a.,	.4768
2.5 Mercury, mean,	.9677	Earth, m. p.,	.9661
1.5 Mercury, m. a.,	.6832	Venus, s. p.,	.6722
1.5 Mercury, s. a.,	.7152	Venus, mean,	.7232
1.5 Venus, s. p.,	1.0084	Earth, mean,	1.0000
1.5 Earth, s. p.,	1.3984	Mars, m. p.,	1.4032
2.5 Jupiter, s. p.,	12.2158	⅔ Uranus, m. p.,	12.2153
1.5 Saturn, m. a.,	15.0001	½ Neptune, mean,	15.0169
1.5 Uranus, m. a.,	30.0663	Neptune, mean,	30.0339
.6 Neptune, s. a.,	18.2817	Uranus, m. p.,	18.3230

The ratio of the rotating radius to the projectile radius of mean rotary *vis viva* is 2.5 ; the reciprocal ratio gives the vector-ratio in opposition, 1.5 ; the ratio of the rotating radius, less that of the projectile radius is .6 ; the reciprocal of 1.5 is ⅔, which also represents the centre of linear oscillation and the radius of subsidence-collision ; the viscous rupturing radius of subsidence is ½.

371. *Reaction of Rotary Vis Viva.*

A fact which has an important bearing on Delaunay's hypothesis, as well as on the second law of thermodynamics, is shown by the reciprocal ratios of the foregoing note, and more strikingly, by the reactionary influence of Neptune. If we look to a like reaction on the part of the other planets, we find the following harmonic accordances :

.6 Uranus, m. a.,	12.0265	.4 Neptune, m.,	12.0135
.6 Uranus, s. p.,	10.6128	Saturn, s. a.,	10.3433
.6 Saturn, s. p.,	5.2407	Jupiter, m.,	5.2028
.6 Jupiter, m.,	3.1217	Asteroid 120,	3.121
.6 Jupiter, m. p.,	2.9869	Asteroid 61,	2.987
.6 Mars, s. a.,	1.0419	Earth, m. a.,	1.0338
.6 Earth, s. a.,	.6406	Venus, s. p.,	.6722
.6 Venus, m. a.,	.4493	Mercury, m. a.,	.4554
.6 Mercury, s. p.,	.1784	Laplace's limit,	.1696

The greatest deviations are at Earth's secular aphelion or locus of incipient subsidence, and at Mercury's secular perihelion or locus of incipient projection ; the difference in each case being about five per cent. (1.0493 and .9507), and the mean difference being zero. The mean deviation of the four dense planets is only $\frac{1}{10}$ of one per cent. The mean difference in the light belt is about $\frac{2}{3}$ of one per cent., the greatest being that of Uranus, 2.5 per cent. The exactness of Jupiter's influence on Asteroids 120 and 61 is remarkable.

372. *Conservative Reaction.*

It may be readily seen that all the indications of the foregoing note point to a rotary *vis viva* of the several planets, reacting against a similar solar *vis viva*, and having no corresponding indications in opposition to the Sun. These indications are of a character like those which underlie the investigations of George H. Darwin, but their influence upon Sun is accelerating, instead of retarding, while any *quasi*-viscous tidal influence is retarding, instead of accelerating. If the two kinds of influence represent equal actions and reactions, the result would be a precise conservation of centripetal and radiant energies, without any solar expansion or contraction, other than in cyclic alternations, within limits of an order of magnitude like that of planetary eccentricities. The fundamental equality of Note 321 shows that Sun's centripetal rotating energy is wholly photodynamic. We may readily believe that the solar rupturing and expanding tendencies of planetary rotation represent a purely photodynamic reaction on gravitating action, which is exactly equivalent and opposite. The evidences of such equivalence in cosmical aggregations should encourage us to look, with increasing confidence, for further evidences in æthereal oscillations of various kinds, and especially in the electric and thermal undulations which are indicated by the fundamental equality. Edlund's researches point to electric and thermal equivalence of action and reaction, as plainly as Maxwell's point to electric and photic equivalence, and as my own point to a like photic, electric, thermal and gravitating equivalence.

373. *The Testimony of Mars.*

The many indications which I have found, of subsidence-orbital relations between Mars and the asteroidal belt, are supplemented by the direct and reciprocal influences (2.5 and 1.5 ; see Note 370), of solar photodynamic rotation upon the secular apsides and the mean locus of Mars, as well as upon intermediate positions.

2.5 sec. per.,	3.277	.6 Jupiter, m. a.,	3.256
1.5 sec. per.,	1.966	½ Asteroid 153,	1.977
2.5 mean,	3.809	.4 Saturn, m,	3.815
1.5 mean,	2.286	Asteroid 136,	2.287
2.5 sec. aph.,	4.341	.8 Jupiter, m. a.,	4.342
1.5 sec. aph.,	2.605	Asteroid 132,	2.603
.4 sec. aph.,	.695	Venus, m. p.,	.698
Mean	2.711	Mean	2.711

The greatest deviation is ⅔ of one per cent. The two mean asteroidal accordances are nearly as exact as those in Note 371. All of the direct and reciprocal influences are in the asteroidal belt. The direct influence at secular aphelion (4.341) points to a "viscous" rupturing influence of the Jupiter-Saturnian belt (.4 of 10.855 = 4.342). The exact agreement of the general means is very satisfactory.

374. *Centripetal Influence of Rotary Vis Viva.*

Some of my critics have supposed that it would be possible to find harmonic accordances with series which were taken at random, or with no known kinetic basis, but none of them have offered any such accordances to confirm their supposition. I have never published any harmonies which were not the natural outgrowth of well-known elastic laws, and the abundant confirmation which I have found for my anticipations is beyond all cavil or gainsaying. In Note 370 I gave evidences of the centrifugal influence of rotary *vis viva*, which may be compared with the following evidences of mean centripetal influence.

.4 Neptune	12.014	⅔ Uranus, m. p.,	12.215
.4 Uranus,	7.673	½ (Jup. and Sat.), m. a.,	7.714
.4 Saturn,	3.816	2.5 Mars,	3.809
.4 Jupiter,	2.081	⅔ Asteroid 120,	2.081
.4 Asteroid 3,	1.067	Earth, s. a.,	1.068
.4 Asteroid 4,	.944	Earth s. p.,	.932
.4 Mars,	.609	Venus, s. p.,	.672
.4 Earth,	.400	Mercury, mean,	.387
.4 Venus,	.289	Mercury, s. p.,	.297

375. *Lines of Force and of Motion.*

Taylor (*op. cit.* p. 28), very properly calls attention to the fact that "no atom can perform an oscillation or a revolution, or follow any other path than a straight line, excepting under the coercion of other atoms attracting and repelling. The first law of motion is that of perfect continuity both in amount and in direction. A shuttlecock rebounding in the empty air would not be more conspicuously a dynamic solecism and impossibility than the kinematists 'vibratory particle.'" His doctrine (*Ib.* p. 9), that elasticity is "a fact of nature, a property of matter, which can neither be interpreted by any form of motion, nor resolved into any mechanical concept," is in precise accordance with the due regard to "lines of force" which guided Boscovich and Faraday, and which has been very helpful in my own researches. My first paper on barometric estimates of solar mass and distance (*Proc. Amer. Phil. Soc.*, ix, 283–8) was attacked by kinematists, because it violated some of their preconceived notions respecting the composition and resolution of forces. It did not receive much favor, until the productiveness of the harmonic methods showed that the composition and resolution of motions, in elastic media, may often enable us to dispense with intricate integrations, which it would be difficult, if not impossible to solve, and that it is always safer to be guided by the FACTS of nature, than by any preconceived theoretical interpretation of those facts.